Projected Global SWE Changes from High-Resolution Land Surface Simulations

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Earth Information System efforts open and accessible science for improving understanding of the earth system

earth information system

EIS is a NASA-wide effort that **integrates NASA's Earth Science observations and modeling capabilities** to produce new science and support decision making.

Fire

Freshwater

Sea Level Rise

Greenhouse Gases

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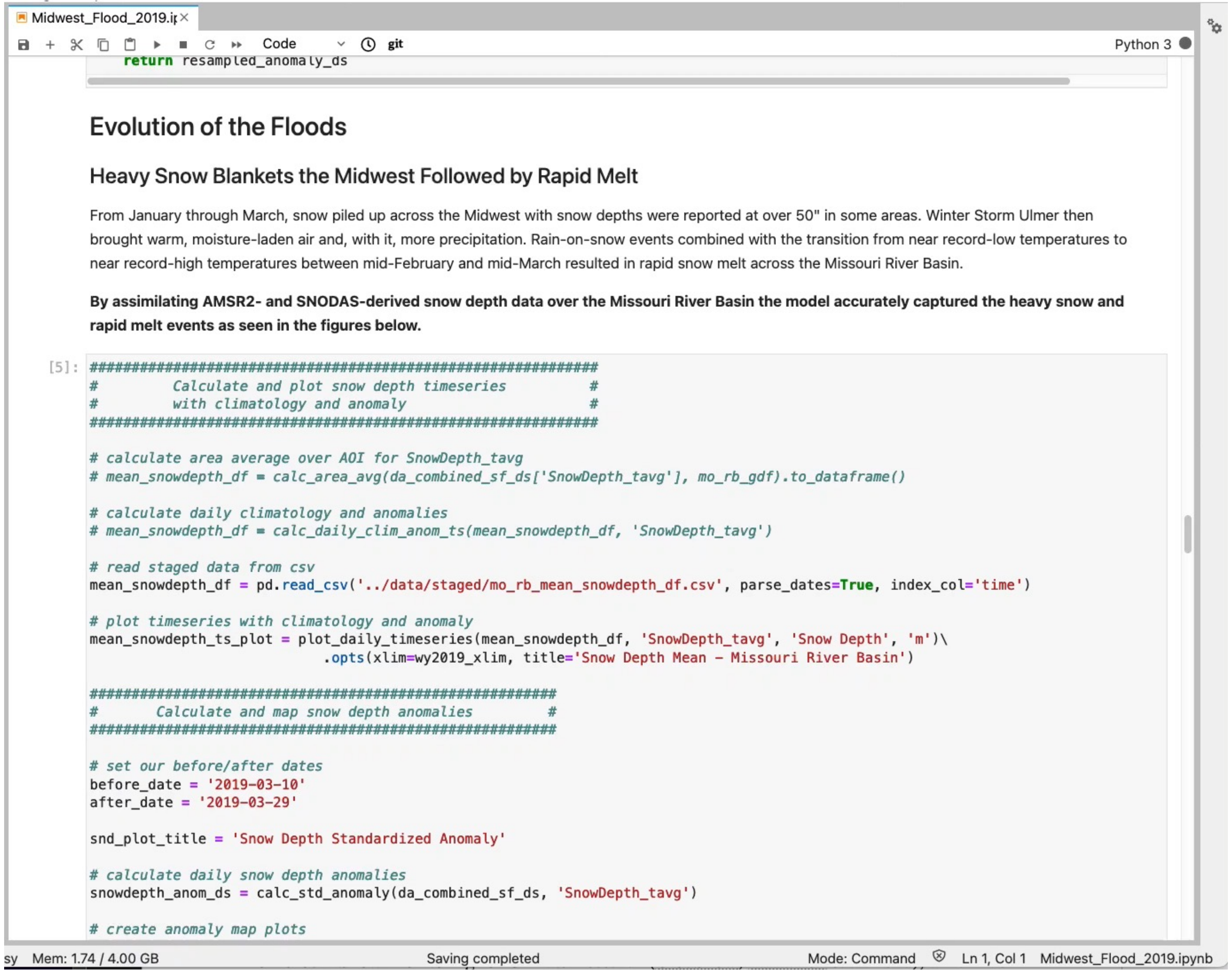
EIS is a NASA-wide effort that **integrates NASA's Earth Science observations and modeling capabilities** to produce new science and support decision making.

- Synthesize information about the water cycle by integrating available **remote sensing data** with advanced **models and data fusion tools**
- Provide an **open science environment** for addressing water security challenges facing the society
- Work with relevant **stakeholders** to provide **actionable information** about freshwater availability, quality, variability, and extremes

See https://eis.mysmce.com/ for more information!

Visit the project website at eis.mysmce.com/



Midwest_Flood_2019.ip

Code

git

Python 3

```
    return resampled_anomaly_ds
```

Evolution of the Floods

Heavy Snow Blankets the Midwest Followed by Rapid Melt

From January through March, snow piled up across the Midwest with snow depths were reported at over 50" in some areas. Winter Storm Ulmer then brought warm, moisture-laden air and, with it, more precipitation. Rain-on-snow events combined with the transition from near record-low temperatures to near record-high temperatures between mid-February and mid-March resulted in rapid snow melt across the Missouri River Basin.

By assimilating AMSR2- and SNODAS-derived snow depth data over the Missouri River Basin the model accurately captured the heavy snow and rapid melt events as seen in the figures below.

[5]:

```
##############################################################
#         Calculate and plot snow depth timeseries           #
#         with climatology and anomaly                       #
##############################################################

# calculate area average over AOI for SnowDepth_tavg
# mean_snowdepth_df = calc_area_avg(da_combined_sf_ds['SnowDepth_tavg'], mo_rb_gdf).to_dataframe()

# calculate daily climatology and anomalies
# mean_snowdepth_df = calc_daily_clim_anom_ts(mean_snowdepth_df, 'SnowDepth_tavg')

# read staged data from csv
mean_snowdepth_df = pd.read_csv('../data/staged/mo_rb_mean_snowdepth_df.csv', parse_dates=True, index_col='time')

# plot timeseries with climatology and anomaly
mean_snowdepth_ts_plot = plot_daily_timeseries(mean_snowdepth_df, 'SnowDepth_tavg', 'Snow Depth', 'm')\
                            .opts(xlim=wy2019_xlim, title='Snow Depth Mean - Missouri River Basin')

#########################################################
#       Calculate and map snow depth anomalies          #
#########################################################

# set our before/after dates
before_date = '2019-03-10'
after_date = '2019-03-29'

snd_plot_title = 'Snow Depth Standardized Anomaly'

# calculate daily snow depth anomalies
snowdepth_anom_ds = calc_std_anomaly(da_combined_sf_ds, 'SnowDepth_tavg')

# create anomaly map plots
```

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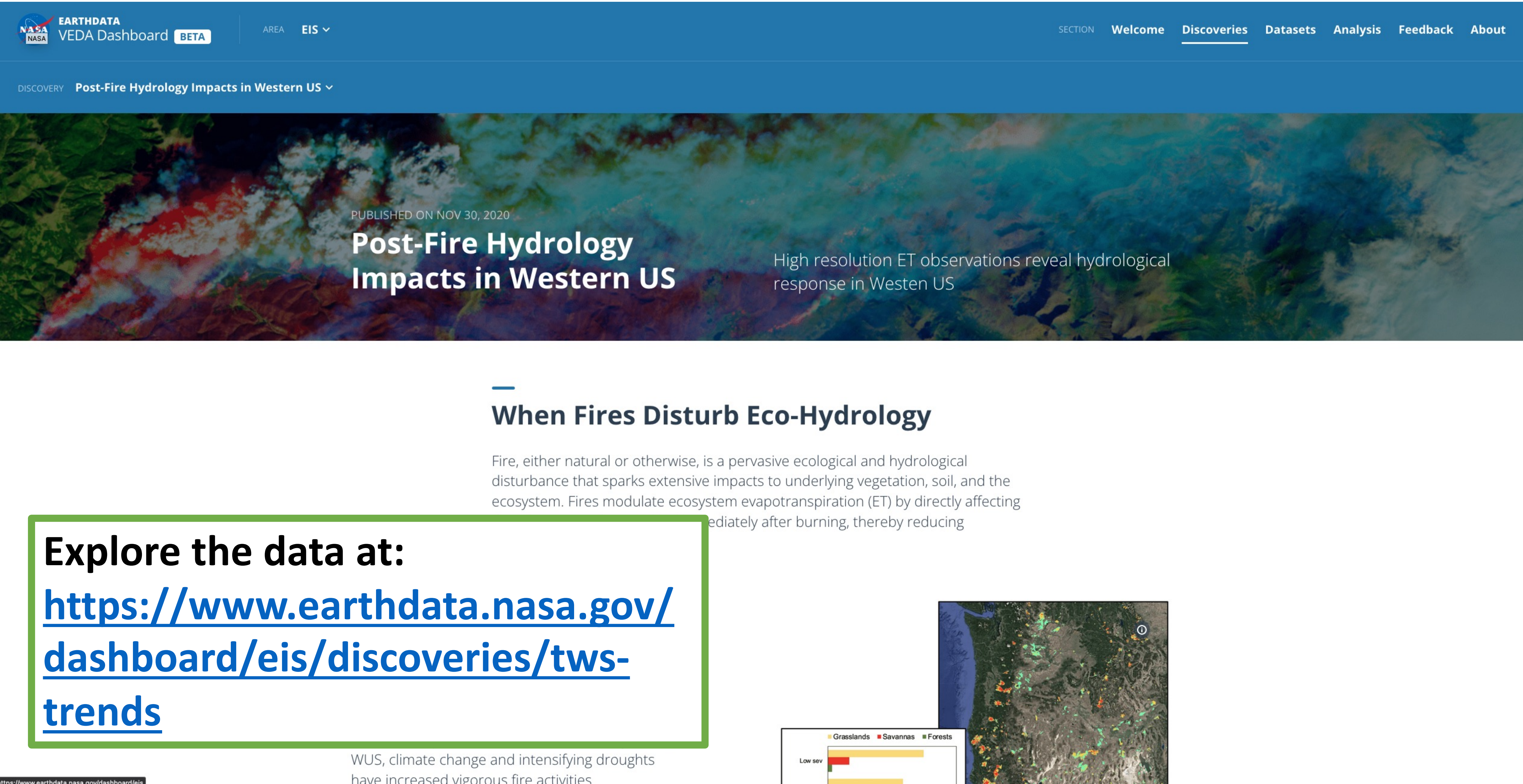
Open science tools

- Development of **Jupyter Notebooks** for case studies allows scientific users to **interact with the data** and perform analyses
- Open science encourages more **community engagement**
- EIS data shared at **SnowEx Hackweek** modeling tutorial

Hackweek tutorials available here: https://snowex.hackweek.io/intro.html

Interactive Discoveries



Explore the data at:
https://www.earthdata.nasa.gov/dashboard/eis/discoveries/tws-trends

EIS focus areas

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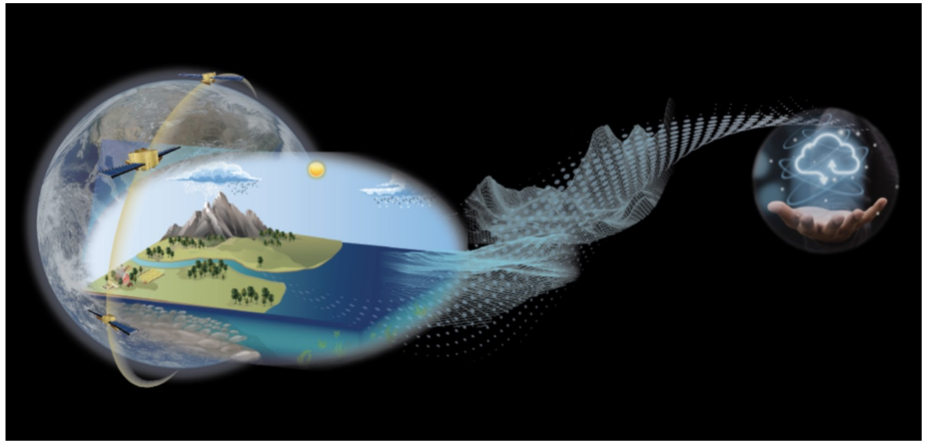
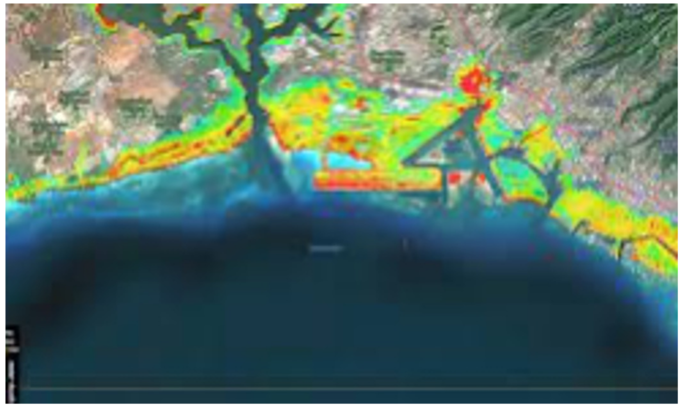
Fire-hydrology interactions

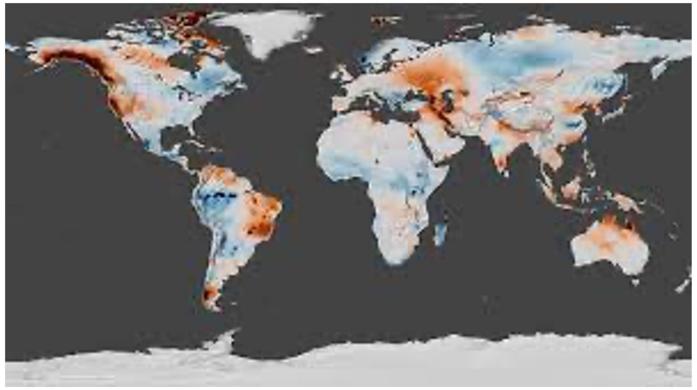


Science translation with AI



Inland and coastal flooding

Water security assessments



Shifts in water cycle fluxes and storage

Downscaling CMIP6 Global Climate Models

- NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP)
- Downscales CMIP6 GCMs to ¼ degree resolution
- Daily data available from 1950 – 2100
- Downscaled using the Bias-Correction Spatial Disaggregation (BCSD) method
- Data available on the NASA Center for Climate Simulation (NCCS)
- 4 Shared Socioeconomic Pathways (SSPs) scenarios

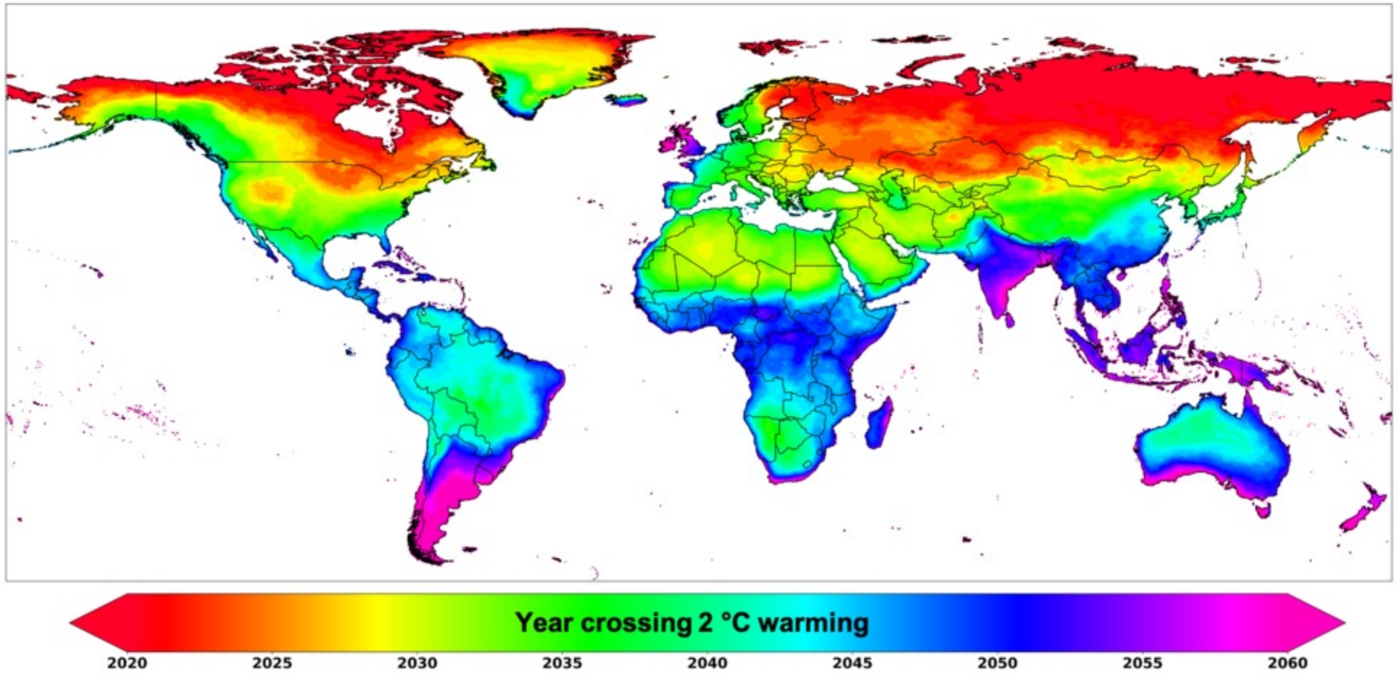
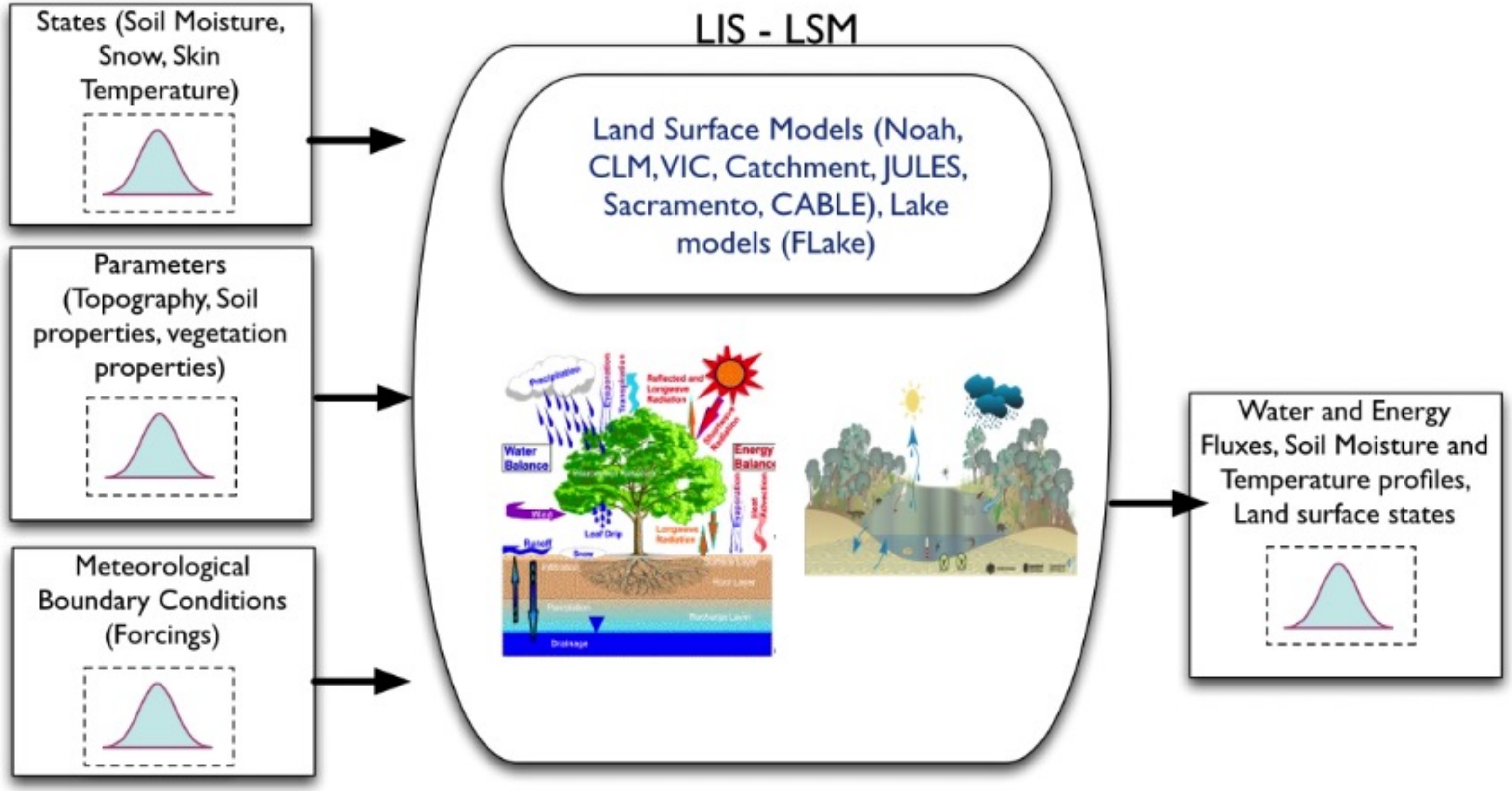


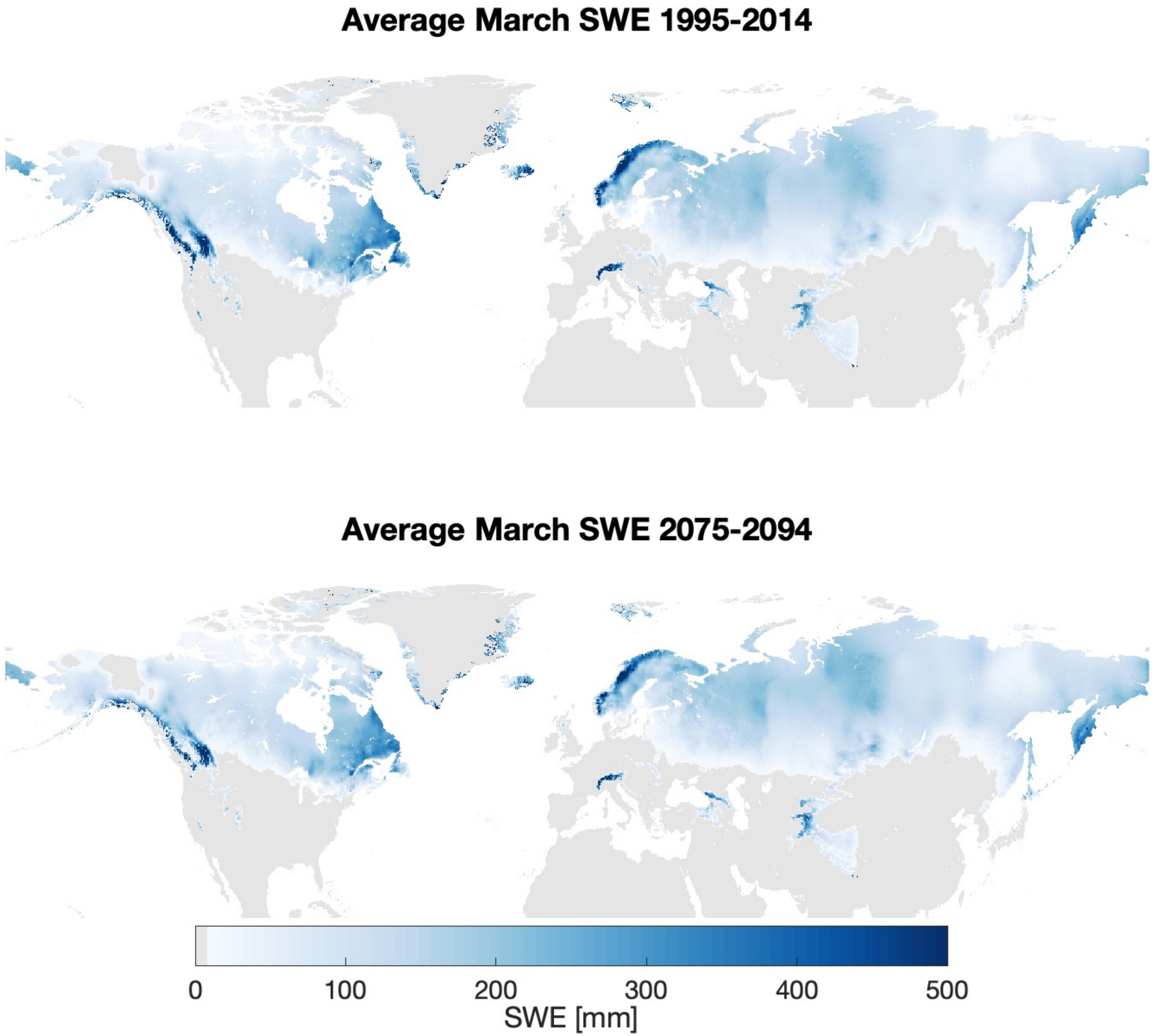
Figure. Spatial pattern of years exceeding the 2-degree warming with respect to the baseline period (1950-1979). The 15-year moving average of the ensemble median of near-surface air temperature from 35 CMIP6 models (SSP585 scenario) was used in detecting the years exceeding the 2-degree warming.

Figure from https://www.nasa.gov/nex/gddp

Model setup and description

- Simulations run using the NASA Land Information System (LIS)
- Global model domain at 10 km spatial resolution
- Forcing data provided by the NEX-GDDP downscaled projections
  - SSP2-4.5
  - SSP5-8.5
- Daily output of land surface variables, including total precipitation, SWE, and temperature
- 23 ensemble members



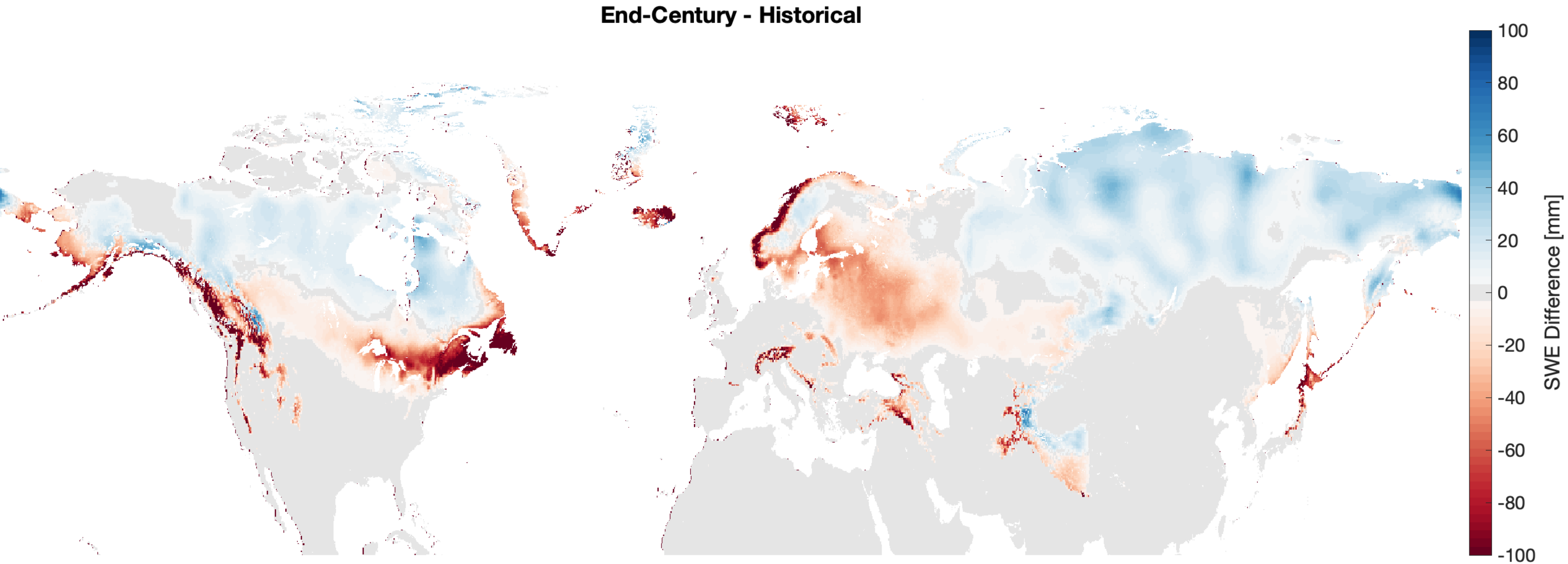


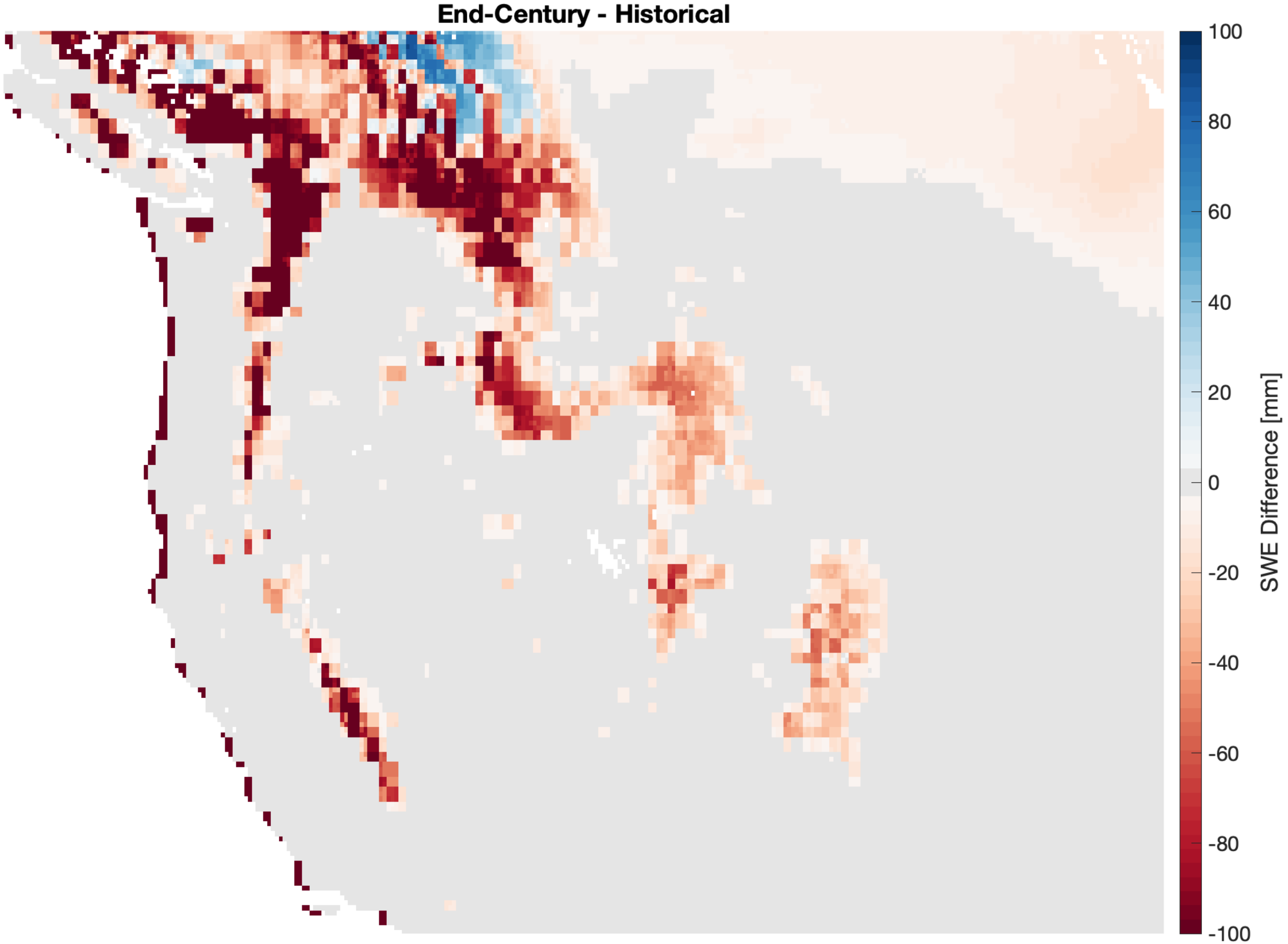
Results: SWE maps

Comparing ensemble-averaged (23 members) March conditions in historical (1995-2014) and end-century (2075-2094) decadal snapshot periods

Results: Projected SWE differences

- SWE decreases in midlatitudes, in coastal areas, and in mountain areas
- Some increases in SWE in higher latitudes

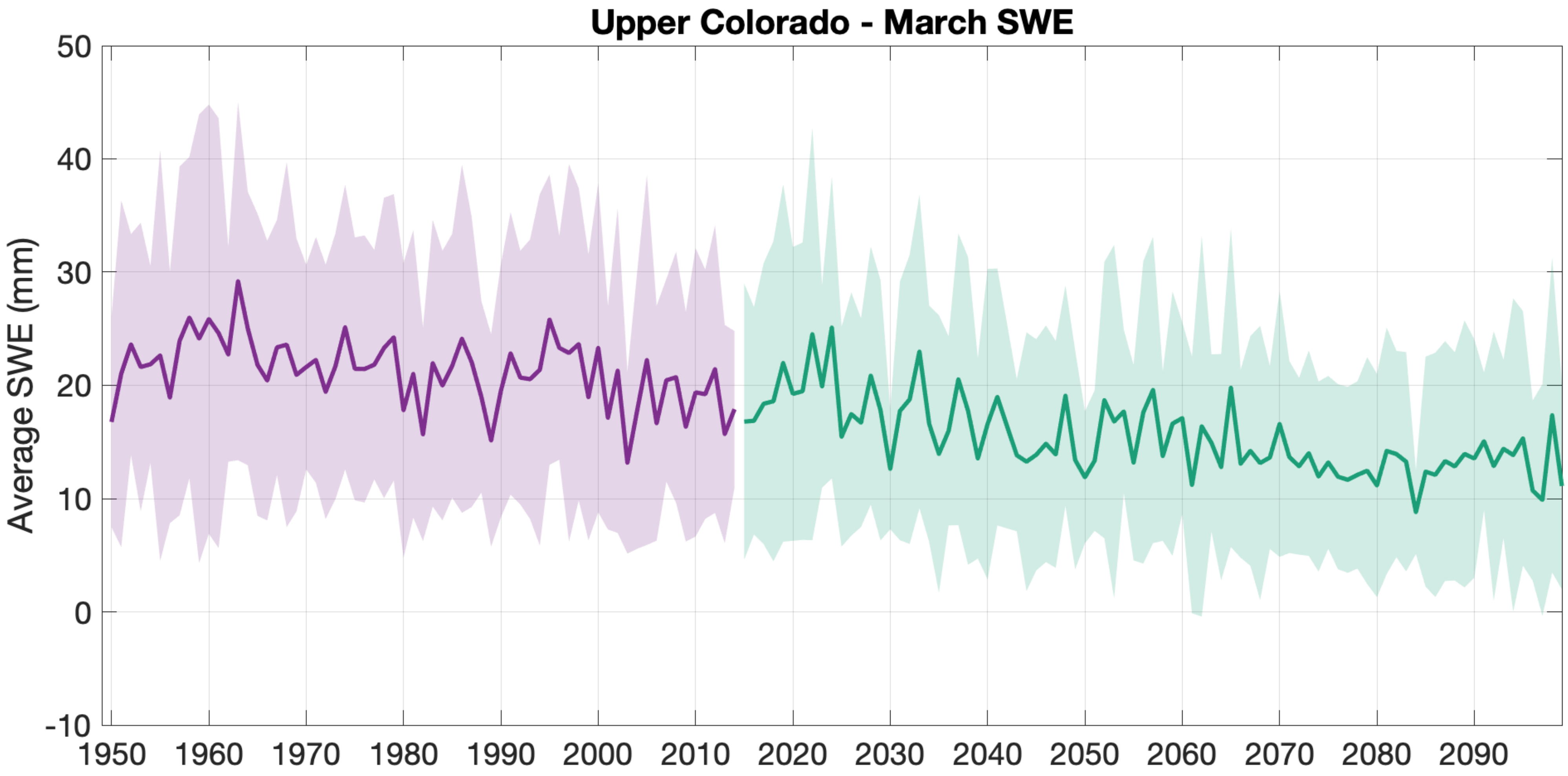


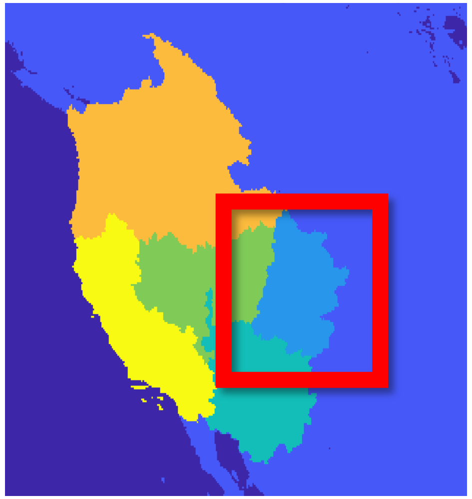


Zooming in:

Projected SWE differences for Western United States

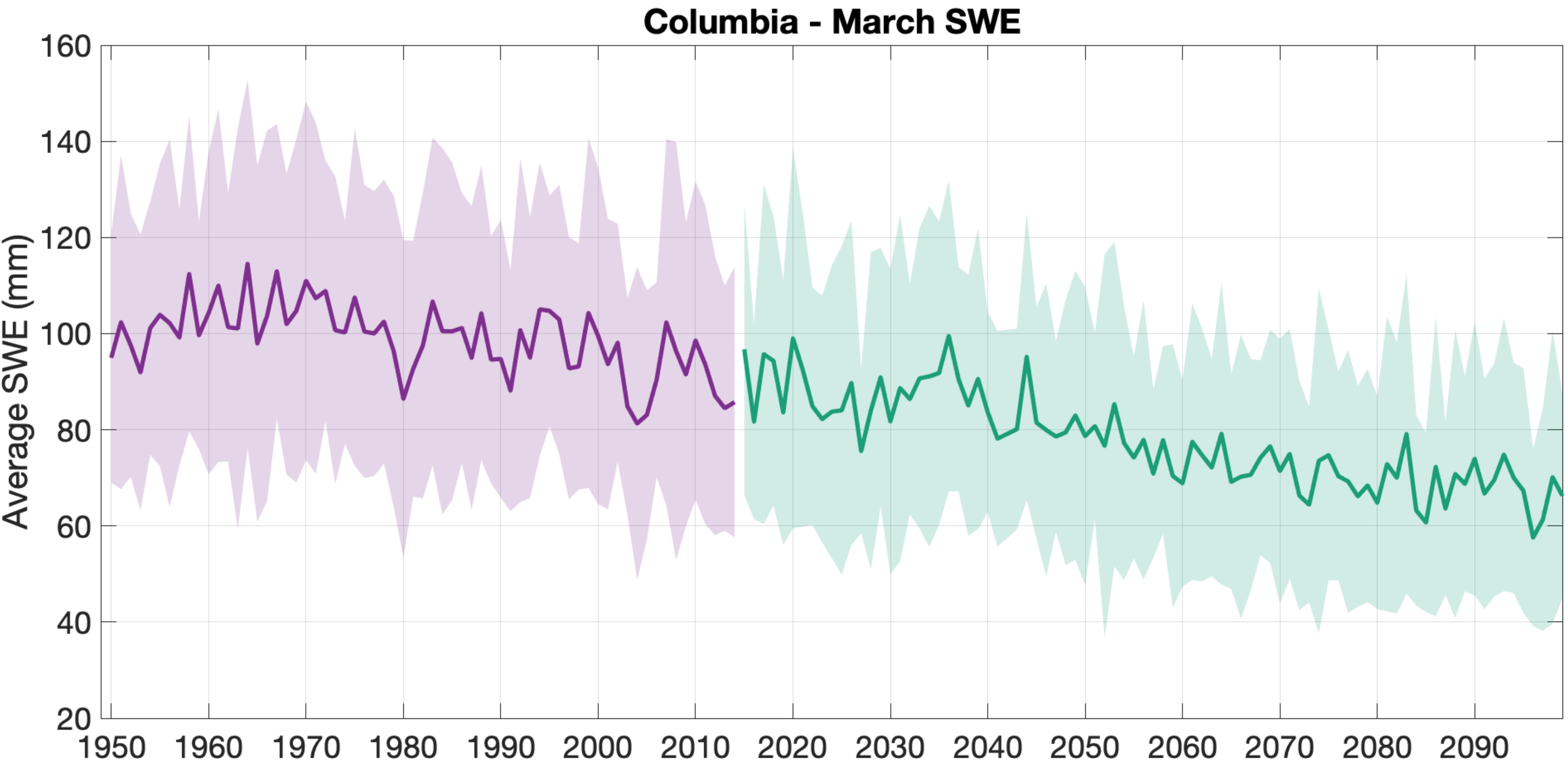
Upper Colorado River Basin average SWE – historical and projected

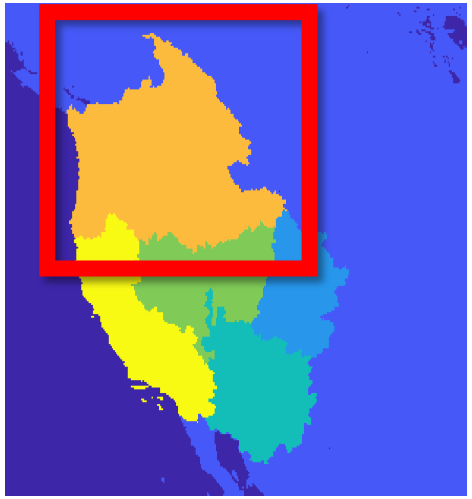




Average SWE for:
1950s: 22.1 ± 13 mm
2090s: 13.4 ± 10 mm

Columbia River Basin average SWE – historical and projected

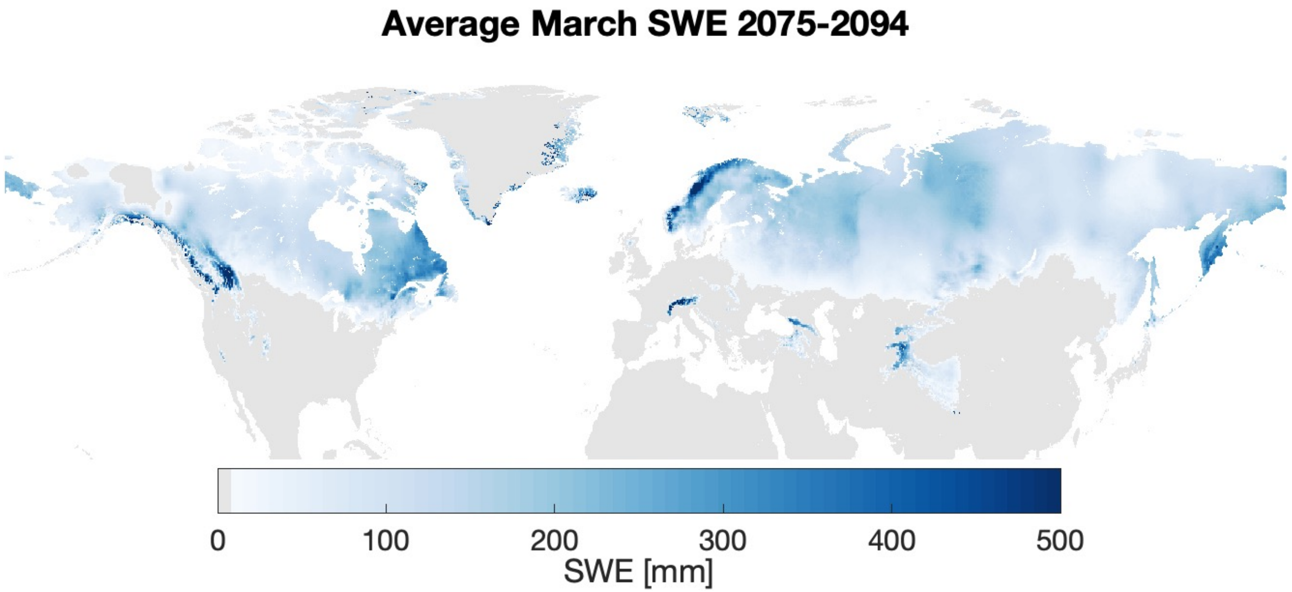


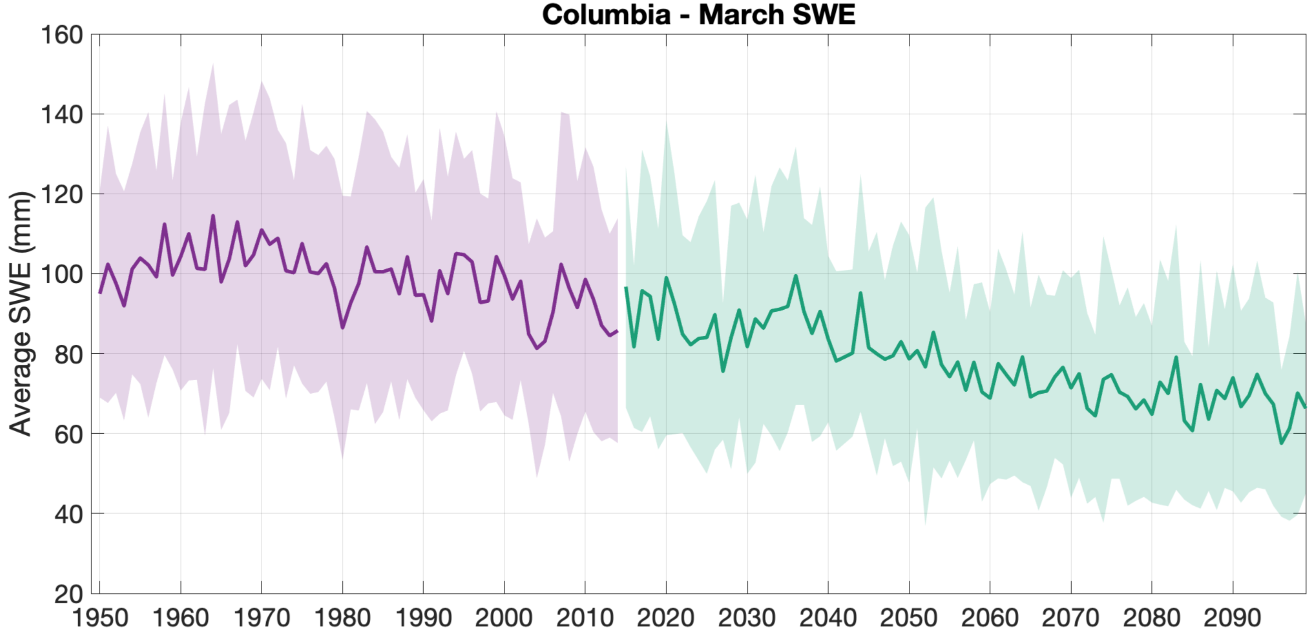


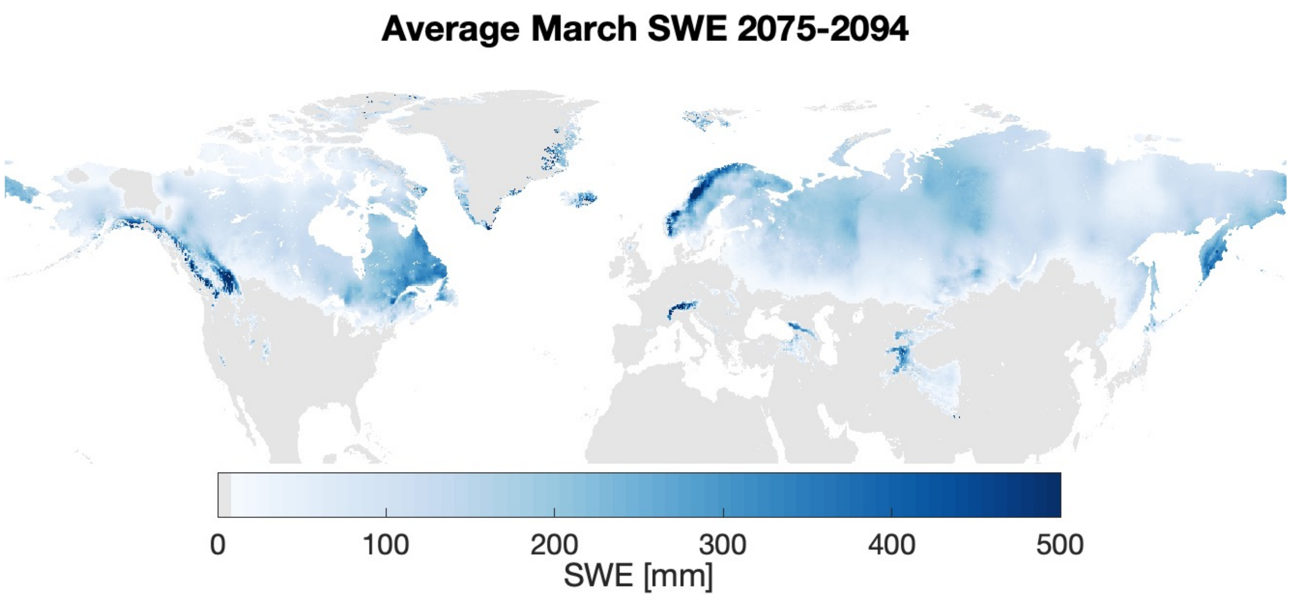
Average SWE for:
1950s: 100.5 ± 30 mm
2090s: 67.8 ± 25 mm

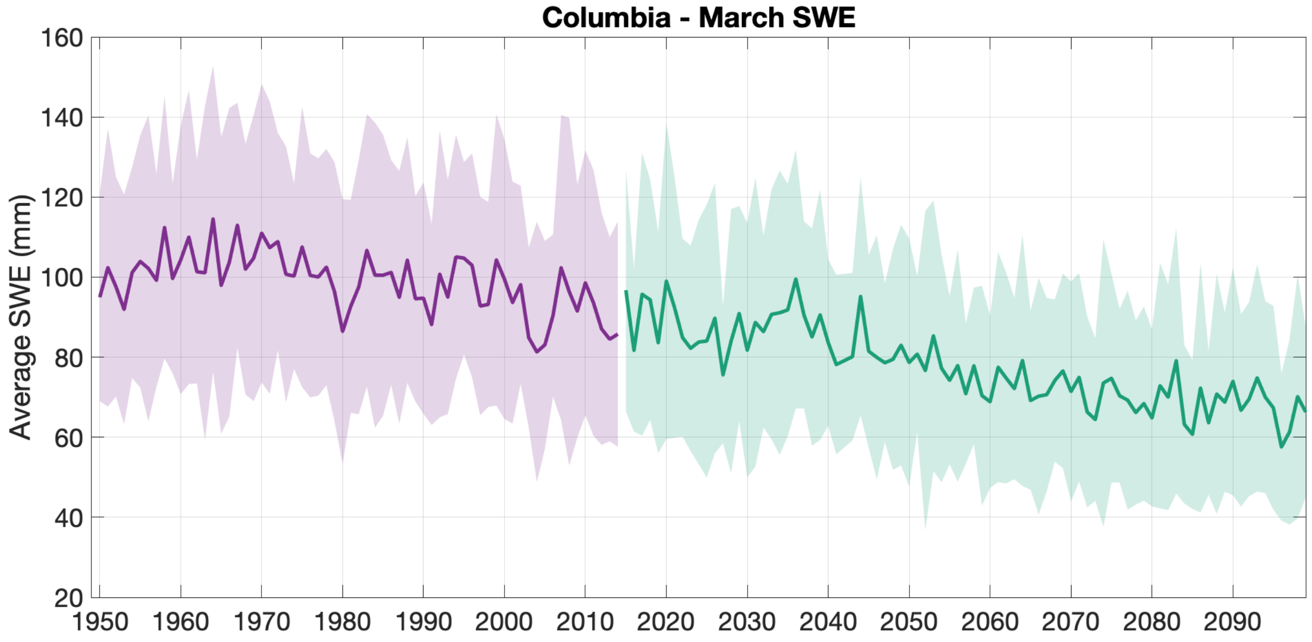
Summary

- Earth Information System efforts are pushing for open and accessible science
  - Designed for scientific and non-scientific community
- Preliminary results from CMIP6-forced land surface model simulations suggest widespread declines in March SWE in midlatitude mountain regions
- Ongoing work considers changes rain-on-snow frequency and intensity









Thank you!

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